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DEVELOPMENT OF A MULTI-SPECTRAL VEHICLE PROTECTION OBSCURATION SYSTEM[1]

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ABSTRACT

Engineering Technology, Inc. (ETI) and the U.S. Army Edgewood Chemical and Biological Center (ECBC) have completed the technology development and application demonstration of a general-purpose vehicle protection obscuration system. The obscuration system employs propellant-based aerosol dissemination technology to expel obscurant materials from launched cartridges and vehicle mounted dispensers. A patent was awarded for this dissemination technology[2,3]. The smoke screen produced by this device is effective in degrading targeting sensors in the visual (VIS) and infrared (IR) spectrum. The operation of the propellant dissemination device presents no measured hazards to dismounted troops outside the visible obscurant cloud.

The smoke dispenser releases the screening aerosol directly from the dispenser unit providing concealment in the immediate area around the vehicle. The projected screening cartridges are fired from a multi-chamber launcher unit and release the screening aerosol away from the vehicle at a range of up to 300m. Each dispenser or launcher and it's electronic firing controller is integrated into a modified M2A1 ammunition container for convenience in handling, storage and use. The total weight of the prototype device is 32 lbs. The electronic controller allows the system to control start of function, the rate of smoke production, and how much of the total payload will be expelled. The controller may be set to produce a single, instantaneous cloud of very dense smoke or a continuous curtain of smoke for up to one minute's duration. This capability provides broad utility for the smoke dispenser or cartridge launcher. A fixed mounted or aimable adaptation with a combination of obscurant dispensers and launchers, in conjunction with threat warning sensors, could be employed for vehicle self-protection smoke applications.

This paper describes a proposed Vehicle Protection Obscurant System (VPOS) and the propellant dissemination technology for this application. Presentation of the paper will include video footage of live test operations and animated, three-dimensional simulations of the overall systems effectiveness.

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[1] This work was funded by U.S. Army SBCCOM under the terms of contract number DAAD13-98-C-0043.

[2] Patent Number 6,047,644, "Propellant Based Aerosol Generation Device and Method of Use", R.J. Malecki, W.G. Rouse, D.J. Hartman, N. Gonzalez

[3] Patent Application, "A Multiple Propellant-Based Aerosol Generating Device and Method of Use", R.J. Malecki, W.G. Rouse, D.J. Hartman, N. Gonzalez

1. Vehicle Protection Obscuration System

A VPOS is a versatile countermeasure protection system providing rapid, quick response, breaklock, protection (hit avoidance), sustained protection to prevent acquisition (acquisition avoidance) and preplanned acquisition avoidance protection for maneuvering across small, short-term regions of high vulnerability. A VPOS is a required subsystem of an integrated vehicle protection system. The following remarks define a VPOS using currently available technology and, to a large degree, currently available or standard subsystems and components. The system is compatible with specialized non-lethal ammunition giving it expanded utility in military operations in urban terrain (MOUT) and crowd control situations. The VPOS and Vehicle Engine Exhaust Smoke System (VEESS), integrated with situation awareness and threat warning systems, and controlled by computerized commander decision aids, can provide manually directed, semi-automatic or automatic responses depending on the tactical situation and the commander's decisions.

The VPOS components/capabilities include the following:

- 2 Aimable, Long-Range Dischargers Protect Forward 120° Sector.
  (Provides 4 screens in each 60° Sector)
- Standard Load - 24 Long-Range RP Projectiles
  (Provides Preplanned VIS, NIR Protection)
- Vehicle Engine Exhaust Smoke System
  (Forty Minutes VIS, NIR Protection - 10 gal Fog Oil)
- 2 Aimable, Quick-Response Dischargers Protect Forward 120° Sector.
  (Provides 4 responses in each 60° Sector)
- Standard Load - 24 Time-Delay Brass Projectiles
  (Provides Rapid VIS, NIR, mid-IR (MIR), FIR Protection)
- 8 Propellant Dissemination Dispensers, 240° Sector
  (Provides Rapid or Continuous VIS, NIR, MIR, FIR)
- 3 Propellant Dissemination Dispensers, Support VEESS
  (Provides 3 Minutes Enhanced MIR, FIR Protection)

All of these components are mounted in fixed positions with manual reload. The maximum amount of obscurant material is carried in a ready-to-use condition. The majority of reloading would occur at ammunition and fuel re-supply points.

The propellant-based smoke dispenser technology described in this paper is an extension of the 40mm screening cartridge work that was previously performed by ETI.[4] The basic packaging and dissemination technology was extended to include multiple cartridges, an electric initiation method instead of a percussion primer, and a self-contained control system. ECBC's Target Defeat Team conceived a concept by which the 40mm VIS/IR/MM wavelength screening cartridges are incorporated into a stand-alone sequencing and firing mechanism to provide a continuous screening or rapid screening capability.

2. Propellant Dissemination Smoke Dispenser

The smoke dispenser housing is a standard ammunition canister approved for storage, handling and commercial shipment of this class of ordnance. A solids model of the smoke aerosol dispenser unit is

[4] Mills, T.E, "Development of a Cartridge for Aerosol Dissemination", Proceedings of the Smoke/Obscurants Symposium XX, ERDEC-CR-270, December 1998, pg 231-240

shown in figure 1. This unit is 11 inches long, 7 inches high and 5.7 inches wide with a maximum weight of 32 pounds when filled with brass powder for infrared (IR) screening. The dispenser unit contains 18

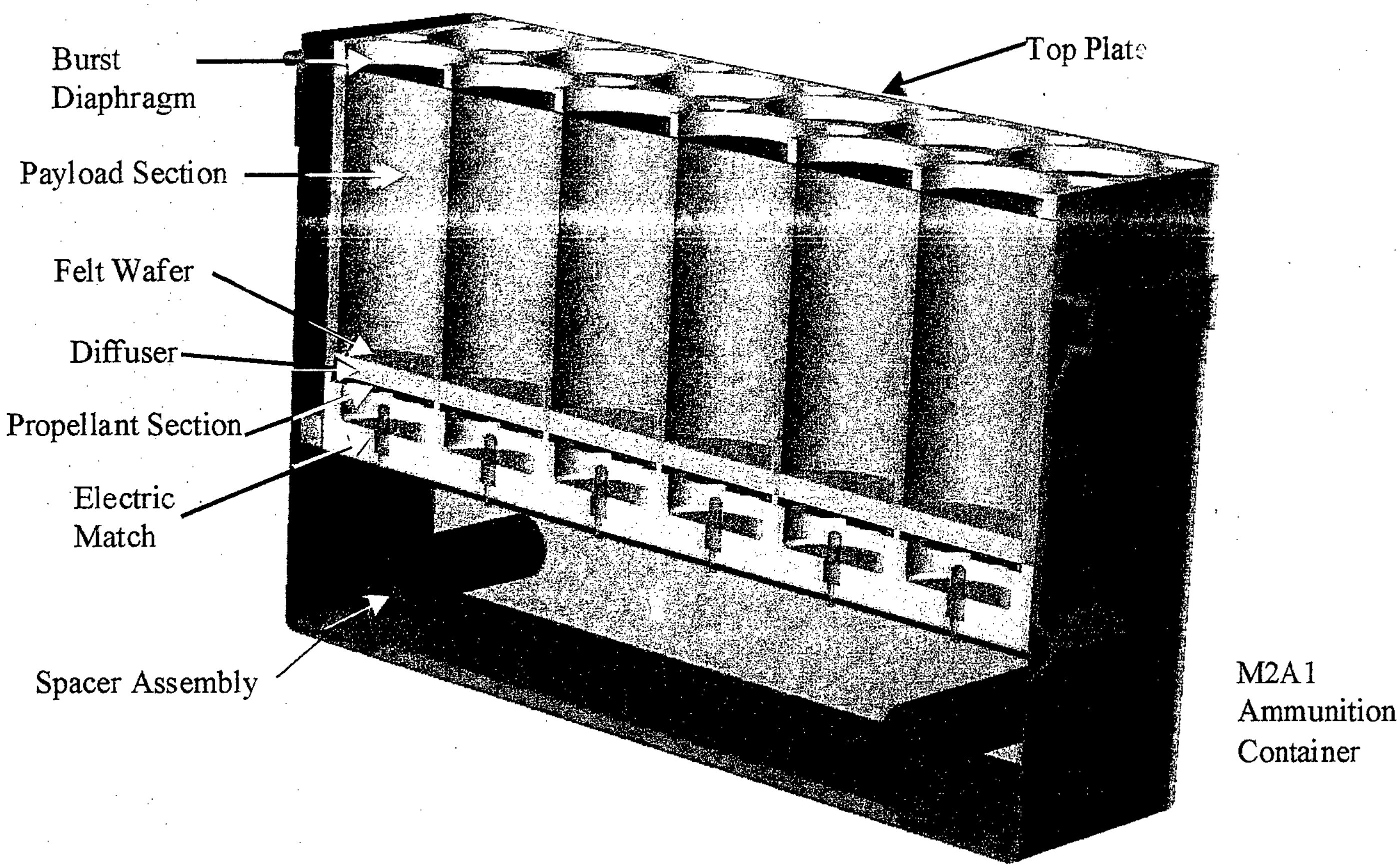


Figure 1. Smoke aerosol dispenser unit assembly configuration.

separate chambers in a vertical orientation. The construction of these chambers is generally consistent with the prior 40mm VIS/IR/MM cartridge design cited in reference 4.

At Eglin AFB a number of trials were conducted wherein the smoke dispensers were operated in a rapid pulsing fashion so as to produce a single dense composite puff to provide a rapid response obscuration function. In these trials, six chambers at a time were functioned with a firing interval of 0.1 second between each sequential chamber initiation. In this manner, three trials were obtained from a single smoke dispenser. The resulting composite puff from one such IR trial is shown in figure 2.

In other trials, the controller was set to provide a longer interval between pulses in such a manner so as to produce a continuous plume result over a longer duration of time. In these instances, a firing interval of either 1.7 seconds or 3.3 seconds was employed, giving an effective function duration "burn time" of either 30 seconds or 60 seconds for a single smoke dispenser. The screening curtain produced from a sequence of three IR chambers fired at a 3.3-second interval is shown in figure 3. As this composite cloud drifts in front of the 20-foot long panel van along the viewers' line of sight, the vehicle is completely obscured from view.

Figure 2. (U) Composite puff produced from a single salvo, 6-chamber quick burst.

Figure 3. (U) Continuous curtain produced from a 3.3-second firing interval.

3. Projected Screening Cartridge and Dischargers

A projected, propellant dissemination cartridge has been developed to provide obscuration function similar to the dispenser technology at a projected standoff distance away from the source. Its end function is identical to the smoke dispensers described in the previous sections. The cartridges are launched from a multiple-shot discharger that is packaged in a modified M2A1 ammunition container. Upon ground or surface impact of the cartridge, an obscuring cloud is produced. Single or multiple cartridges, up to 12 currently, could be functioned at ranges up to 300m.

The cartridge (figure 4) has overall dimensions of 1.8in outside diameter x 11.2in long (in-flight configuration with fins deployed), weighs 1.04lb (empty) and has a cylindrical payload section volume of 121cc (35.7mm Dia x 121.4mm L). The impact fuze uses a mass inertial mechanism, in which a weight, which houses an M209 percussion primer, slides inside a bore. Upon ground impact, the slider's inertia causes it to move forward striking a firing pin which initiates the primer. The primer then ignites the propellant charge thus starting the aerosolization process. The smoke-producing fill is encapsulated within this volume by the cartridge's aluminum casing and a threaded burst diaphragm set to rupture at 1000psi nominally. The diffuser helps in the mixing of fill particles with the gas. Upon aerosolization of the particulate fill, the payload is ejected from the base of the cartridge. The felt discs, in addition to being flame retardant, wipe the bore clean of any remaining fill that did not get expelled from the cartridge.

For flight stability, the cartridge uses a retractable fin assembly. The fins are spring-loaded to allow the cartridge to be loaded into the launch tube. Upon ejection from the launcher, the fins spring out radially and slide rearward, providing the necessary stability.

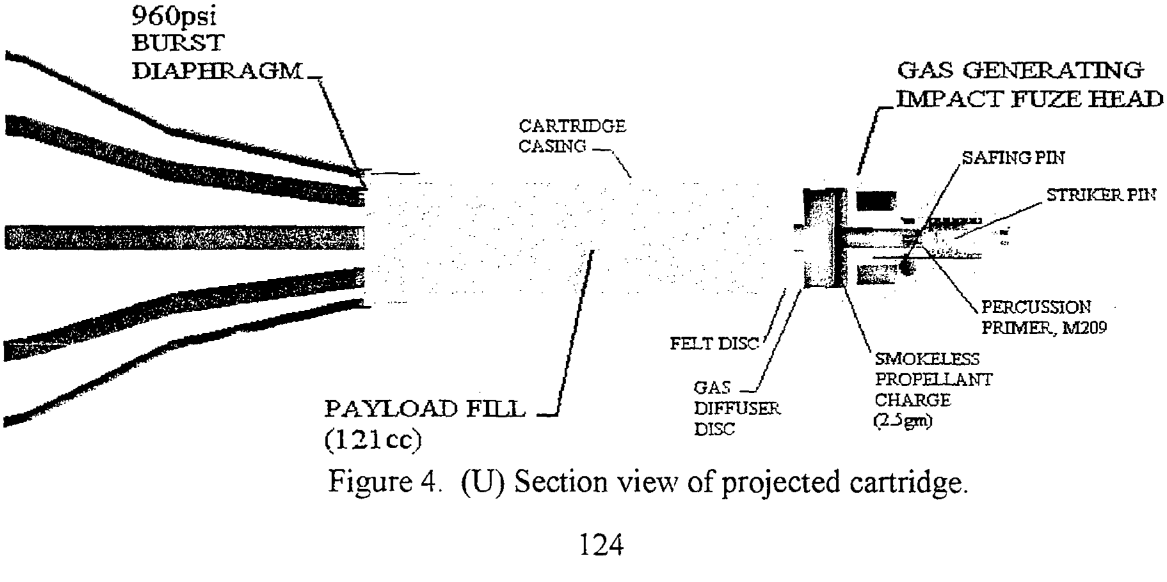


Figure 4. (U) Section view of projected cartridge.

A variation of the impact functioning projected cartridge is under development. This cartridge uses a programmable electronic delay system. The electronic delay replaces the impact fuze employed in the current design with minimal alterations to the existing hardware. The payload section of the cartridge remains unchanged. The delay is capable of functioning in the 0.1 to 9.0-second range, with an accuracy of 0.0001 sec to provide air burst functioning of the round in flight. The application of such a cartridge would be used in all range applications to provide precise positional control over cloud formations. A concept of the electronic delay system is shown in figure 5. The user can set the delay time from the control unit immediately prior to ejection from the launcher device. This allows programming individual cartridges to function at different times and also provides greater operational safety.

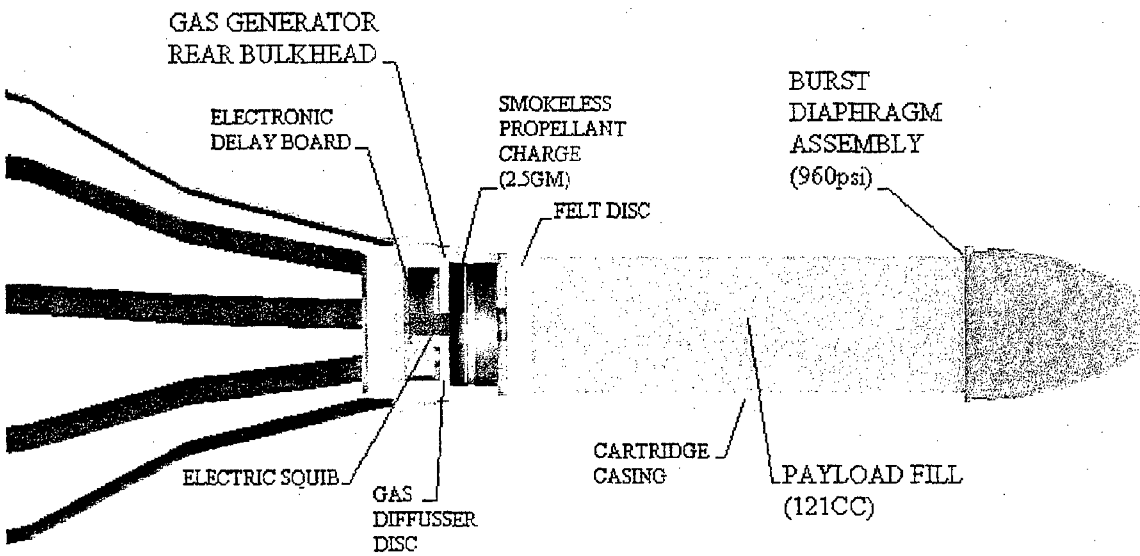
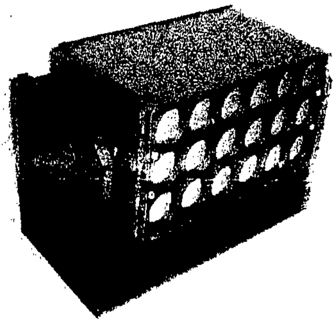


Figure 5. (U) Electronic timed delay fuze head for projected screening cartridge.

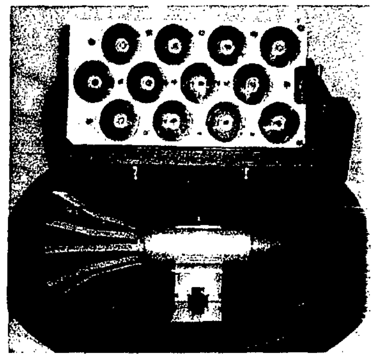
5. Vehicle Protection Implementation Concept

To provide ground vehicle self-protection against direct-fire combat, the propellant dissemination dispenser and screening cartridge discharger system could be used in an onboard, mobile pre-planned or rapid screening application. The dispenser and discharger hardware could be adapted to either a fixed installation mounting or a two-axis motor driven turret. Dispenser hardware concepts and mounting arrangements are shown in figure 6. In these applications, the firing control is integrated with the vehicle threat detection sensors and countermeasures system. Empty dispenser units may be replaced quickly in the field. It would also be possible to devise an autoloader for this application.

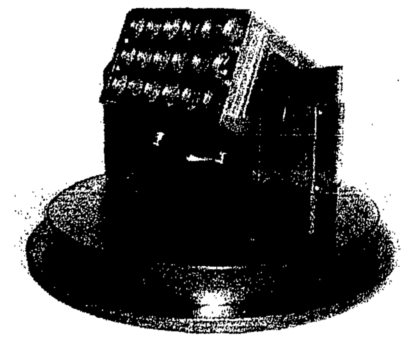
A scenario was devised to illustrate the simulation of the VPOS against visual and IR guided threats. The scenario is illustrated in figure 7. The wind is coming from the west at 3 m/s. The vehicle is traveling north and approaches an open area it knows is under surveillance by the enemy. To avoid acquisition at time "0 seconds" a salvo of three long range 40mm RP projectiles are fired to provide visual and NIR protection. At +9s the cloud begins to form and at +10s the vehicle begins its maneuver to cross the open area. At +14s the VIDS detects an IR quided missile attack to the right of the protected area so the rapid response projectiles are aimed to the left 15° and a small breaklock protective screen from 3 IR projectiles is formed at +15s. As the vehicle continues to maneuver to cover, IR reacquisition prevention obscurants are functioned at time +18s, +23s, and +28s, and a 1-minute sustained IR screen is initiated at time +34s. The vehicle continues to maneuver to counterattack and continue with its original mission.



Fixed Installation Mount



Projected screening cartridge discharger unit.



Two Axis Motor Driven Turret

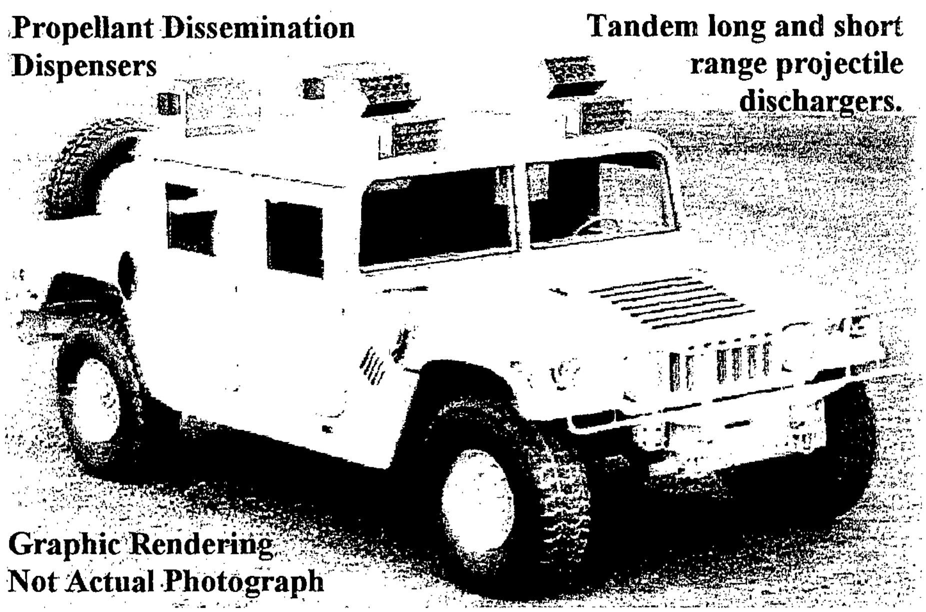


Figure 6. (U) Vehicle self-protection obscurant countermeasure application.

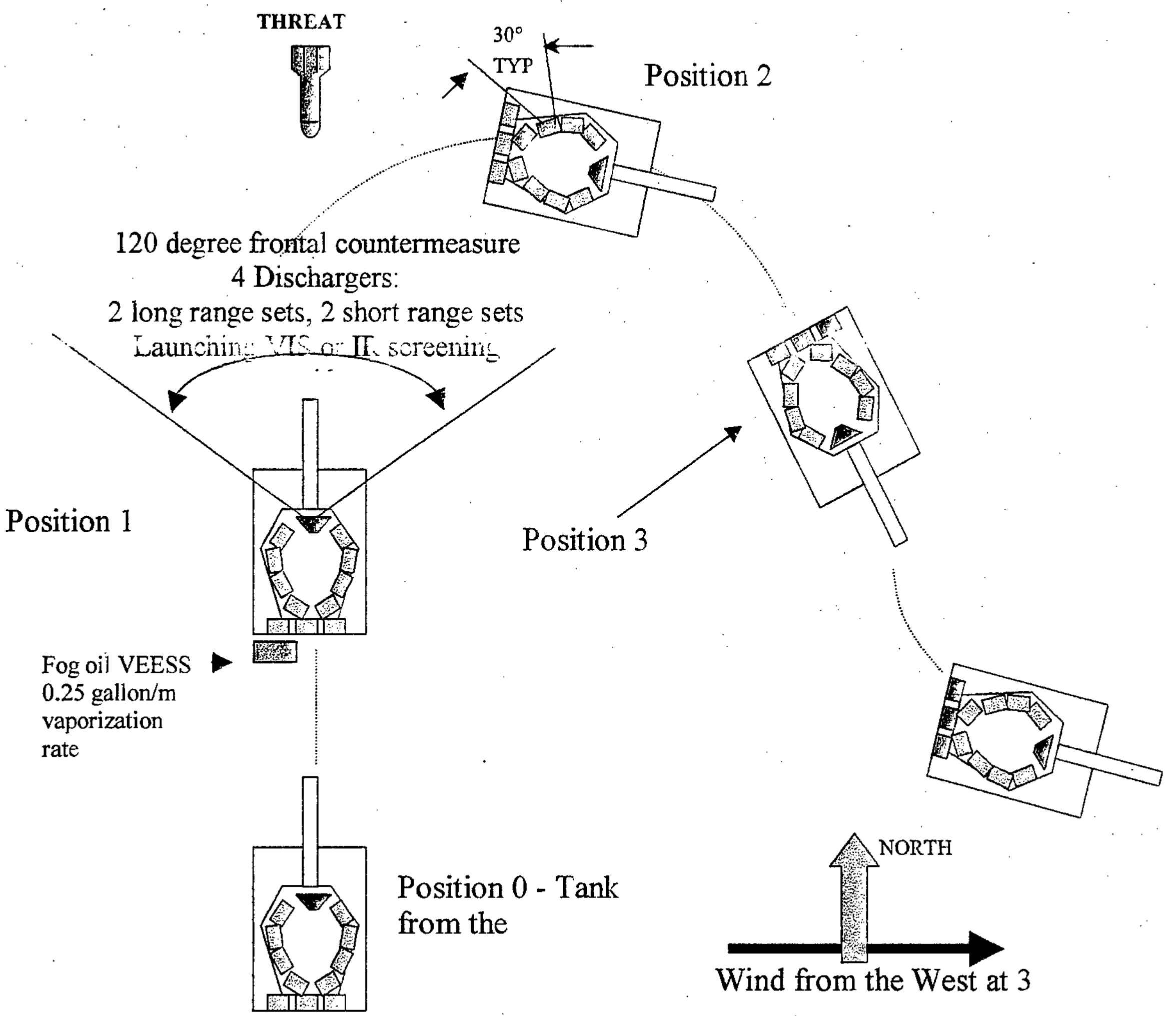


Figure 7. (U) Diagram of vehicle protection system simulation Scenario 1.

Selected frames from the dynamic simulation results are provided in figure 8. In these images, the visible white smoke produced by the RP screening cartridges is shown in white. The IR screening aerosol produced by the brass flake fill in the cartridges and the vehicle protection dispensers are represented as a brown aerosol. In figure 9 the Cloud Density Visualization Utility (CDVis) for SSPM represents the cloud images as seen when viewed in a selected spectrum; VIS, NIR, MIR or FIR. The effectiveness of the visual smoke decreases across the IR spectrum. The screening effectiveness of the brass flake aerosol does not change across the VIS to FIR spectrum because the extinction coefficient for brass flake is generally constant across this spread of wavelengths. The extinction coefficient is an optical property of material particles which is representative of the aerosol screening cross-section per unit mass at a specified wavelength. As illustrated in figure 9, the target vehicles own thermal sights would not be significantly impaired by the visual screening smokes. However, the IR smokes are opaque across the entire visual and IR spectrum. In the simulation, the long-range projectiles establish an initial VIS/NIR acquisition prevention screen. The IR capability of the enemy allows attack with a more sophisticated weapon system, but the VIDS warning systems directs the rapid burst of projected screening cartridges and quickly establishes a curtain of IR protection against the incoming threat. The initial dispenser obscurant releases from the left-side dispensers provide reacquisition screening protection directly coupled to the vehicle followed by sustained IR protection from the continuous dispenser function as the target vehicle moves clear of the vulnerable area and proceeds with counterattacks.

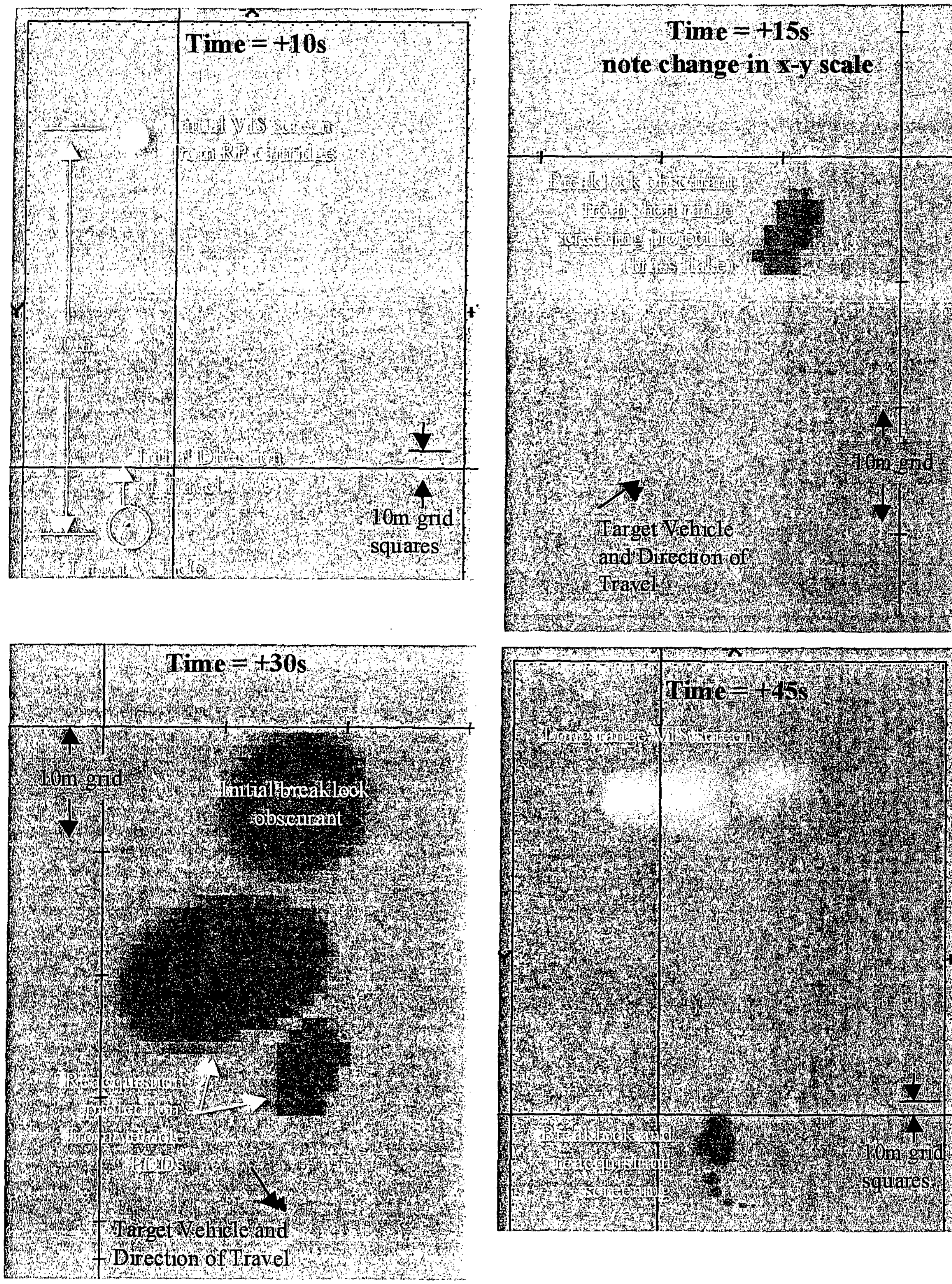


Figure 8. (U) FCS vehicle protection visual screening scenario simulation results. Time sequence of screening aerosol release from SSPM simulation.

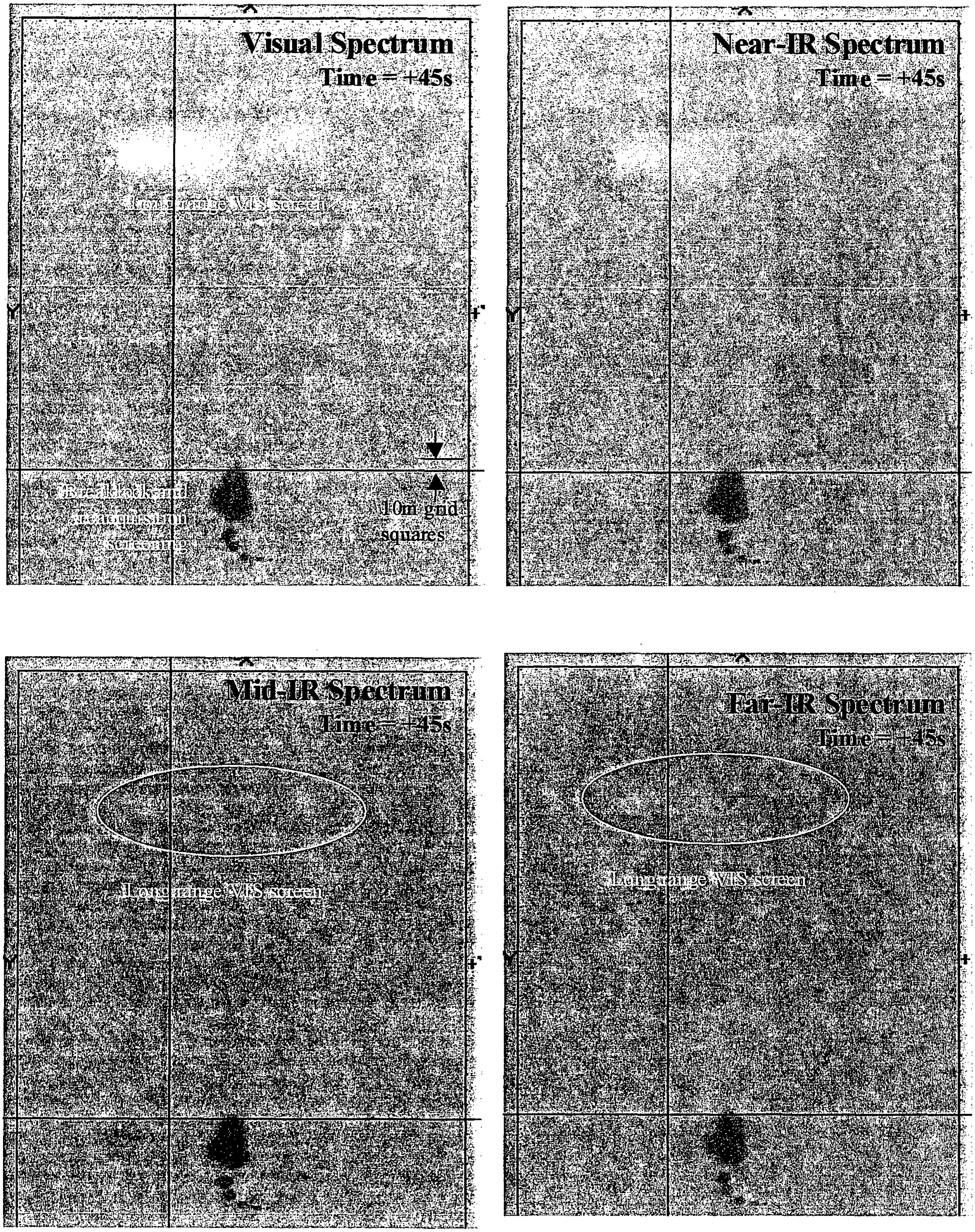


Figure 9. Visual and IR smoke as seen in different spectrum.
Simulation time T0 + 45 seconds.

6. Conclusions

The emphasis for the Interim Army Vehicle (IAV) and Future Combat Systems (FCS) is on rapid deployment, lightweight combat vehicles. Propellant dissemination technology for obscurant countermeasures affords a significant opportunity to replace heavy armor with a low-cost, versatile, multi-spectral and effective vehicle protection suite with the capability to deploy a rapid sensor guided missile countermeasure to achieve break-lock. A comprehensive Electro-optic-Infrared (EO-IR) countermeasure suite will include active electronic detectors and jammers, decoys and obscurants. The propellant dissemination methods and low hazard dispenser technology is dually suited to dispense non-lethal aerosols in urban terrain. The propellant dissemination technology described in this paper is available now.